

for example, the mean flow of Eleven Point River near Thomasville (30) is

only $0.23 (ft^3/s)/mi^2$ or $0.00251 (m^3/s)/km^2$, whereas the mean flow of the same

stream farther downstream below several large springs (31) is 0.92 (ft³/s)/ mi²

32,700

94,400

852 2,654 17.67 1.30

701,000 | 1862-1971 | 1,019,000 | 218,000

Discharge for period of record

SUMMARY OF STREAMFLOW DATA FOR STATIONS SHOWN ON MEAN DISCHARGE MAP

560 1922-71

200 1929-71

528.200 | 1898-1971 |

718 | 1949-71

712,600 1928-71

1,667 1913-71

2,038 1919-71

793 1922-71 40,000

1 06928000 Gasconade River near Hazlegreen 2 06928500 Gasconade River near Waynesville 3 06930000 Big Piney River near Big Piney

4 06932000 Little Piney Creek at Newburg

5 06933500 Gasconade River at Jerome.

6 06934500 Missouri River at Hermann.

7 07010000 Mississippi River at St. Louis.

8 07013000 Meramec River near Steelville.

9 07014500 Meramec River near Sullivan

10 07016500 Bourbeuse River at Union.

12 07018500 Big River at Byrnesville.

13 | 07019000 | Meramec River near Eureka.

14 07020500 Mississippi River at Chester, Ill.

16 | 07022000 | Mississippi River at Thebes, Ill.

17 | 07037500 | St. Francis River near Patterson

18 07039500 St. Francis River at Wappapello

21 07057500 North Fork River near Tecumseh

22 07058000 Bryant Creek near Tecumseh.

23 | 07061500 | Black River near Annapolis

25 07063000 Black River at Poplar Bluff⁵

26 07066000 Jacks Fork at Eminence.

27 07066500 Current River near Eminence

28 07067000 Current River at Van Buren

29 07068000 Current River at Doniphan.

30 07070500 Eleven Point River near Thomasville.

31 07071500 Eleven Point River near Bardley.

Flow regulated by Wappapello Lake since July 10, 1940.

⁵ Flow regulated by Clearwater Lake since June 3, 1948.

Minimum . Median . .

From Taylor (1964).

²Organic and ammonia nitrogen. Not included in computation of median.

Flow regulated by Table Rock Lake since September 9, 1950

Note: Flow of the Mississippi and Missouri Rivers is partly regulated by upstream reservoirs or navigation dams.

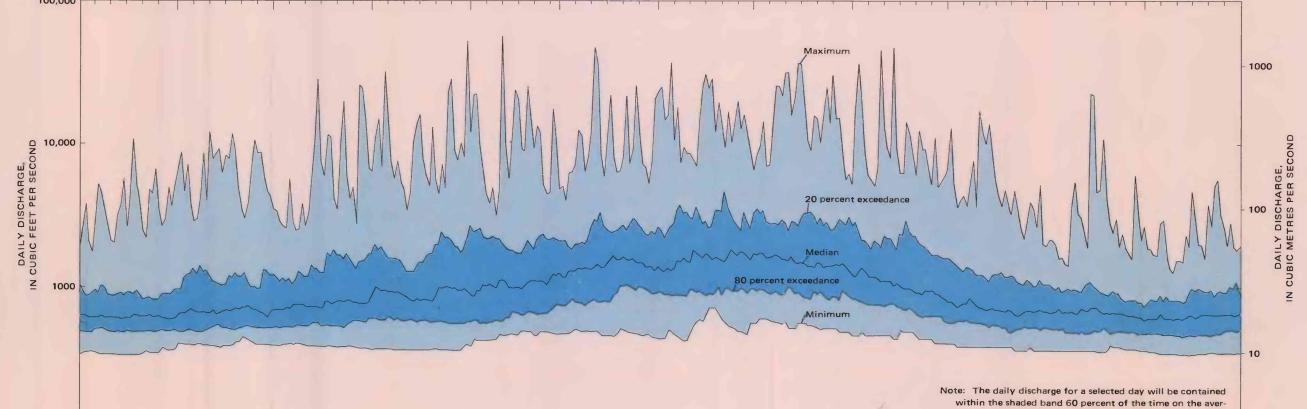
24 | 07062500 | Black River at Leeper⁵

11 | 07018000 | Big River near DeSoto.

15 07021000 Castor River at Zalma.

19 07052500 James River at Galena... 20 07053500 White River near Branson⁴.

SURFACE-WATER AVAILABILITY

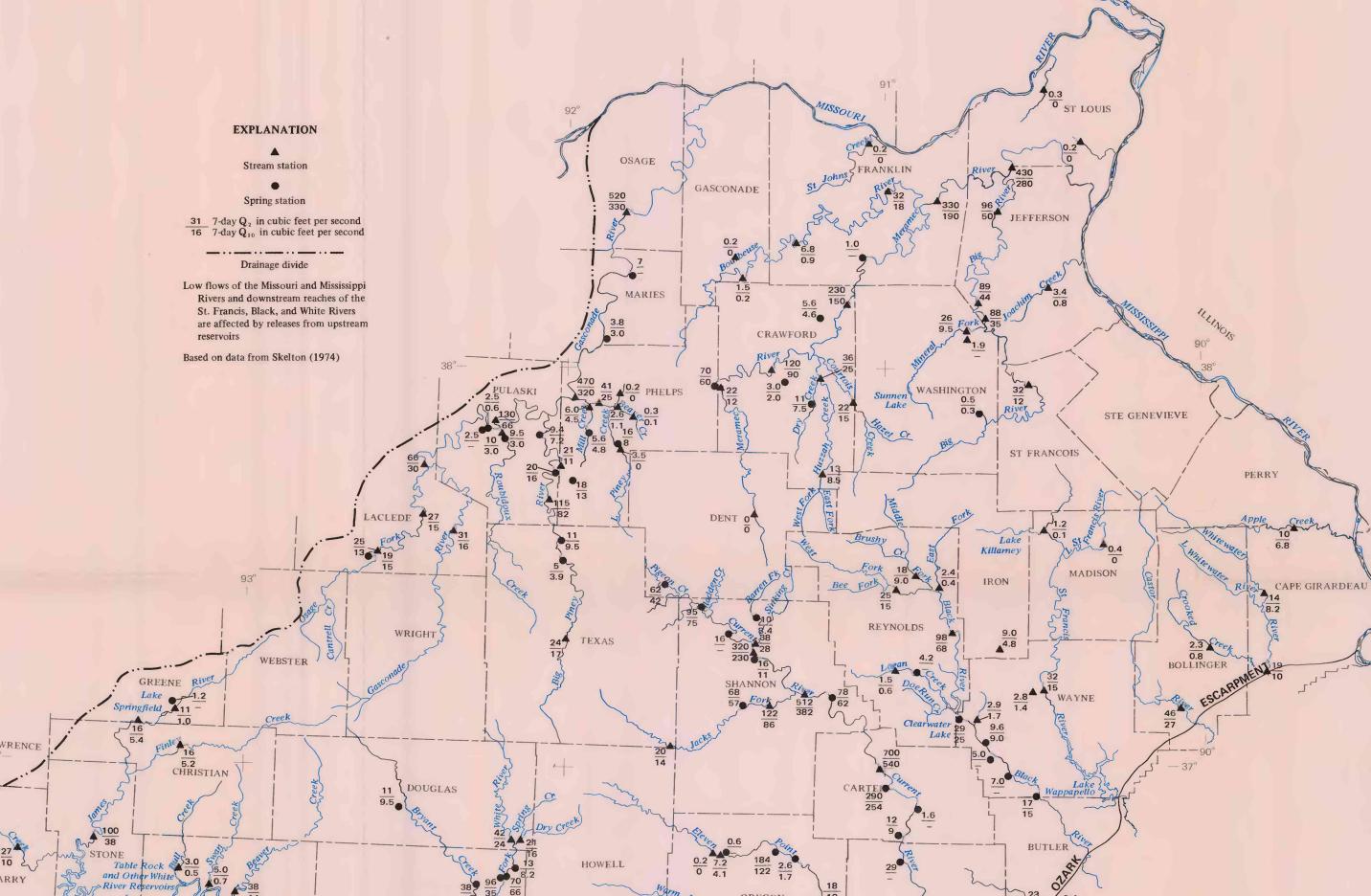


100 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 MONTH AND DAY OF YEAR DURATION HYDROGRAPHS SUMMARIZE THE VARIABILITY OF DAILY FLOWS FOR THE 49-YEAR PERIOD, 1923-71, AT CURRENT RIVER NEAR EMINENCE.—On July 1, for example, the maximum daily discharge is 13,000 ft^3/s (368 m^3/s), the minimum daily discharge is 405 ft^3/s (11.5 m^3/s) and daily discharges that were exceeded 20, 50 (median), and 80 percent of the time are 1,540, 786, and 564 ft³/s (43.5, 22.3, and 16.0 m³/s), respectively. Assuming that the period 1923-71 is representative of the long-term flow of the Current River at this site, the above hydrographs may be used to estimate

the distribution of future daily flows. For example, the daily discharge for July

1 can be expected to fall between 1,540 and 564 ft 3 /s (43.6 and 16.0 m 3 /s) 60

percent of the time on the average. Streamflow characteristics exhibited by the above hydrographs include: (1) Lower flows with less variability can be expected to occur during the August-October period, (2) higher flows at each exceedance level are more likely to occur during the March-May period, (3) extremely high flows may occur in any month but are less likely to occur during September and October, (4) the relatively high position of the minimum hydrograph reflects the well-sustained nature of a springfed stream, and (5) upward trends beginning near the end of October suggest increased streamflow as a result of decreased transpiration by plants.



25 MILES

tions on the same stream. Significant increases generally indicate the presence

of considerable inflow from springs which may occur at one or several points

within the reach. In the Gasconade River basin, for example, more reliable

estimates can be expected between the two stream stations on Osage Fork

than between the two stream stations on Big Piney River. Extrapolations above

the most upstream station on a stream and to ungaged streams are not rec-

ommended because of the possibility of significant losses to subsurface drain-

age. At ungaged sites where more accurate estimates of low-flow values are

desired, 5 to 10 low-flow measurements may be necessary on different reces-

sions in different years for relating to corresponding discharges at nearby sta-

tions where low-flow frequency data are available. Values of the 7-day Q2

range from less than $0.01 (ft^3/s)/mi^2$ or $0.000109 (m^3/s)/km^2$, in the upper parts

of the Bourbeuse, St. Francis, and Eleven Point River basins to more than

Eleven Point, and North Fork River basins.

 $0.50 \ (ft^3/s)/mi^2$ or $0.00545 \ (m^3/s)/km^2$ in parts of the Gasconade, Current,

25 KILOMETRES

The natural flow of principal streams in the area is less than the mean flow approximately 70 to 80 percent of the time and less than the 7-day Q2 flow (see lowflow frequency map) 5 to 10 percent of the time. AVERAGE ANNUAL RUNOFF, IN CENTIMETRES 24 26 28 30 32 34 36 38 40 42 44

streamflow during periods of little rain.

A daily mean flow of 0.052 cubic feet per second per square-

mile (50 ft³/s) can be expected to be exceeded 90 percent of the time in St. Francis River near Patterson. The flow

will be less than 50 ft³/s approximately 10 percent of the

0.1 0.5 1 5 10 20 30 40 50 60 70 80 90 95 98 99 99.9 99.99

FLOW-DURATION CURVES SHOW THE INTEGRATED EFFECTS OF THE VARIOUS FACTORS THAT AFFECT STREAMFLOW .- A curve with a steep slope throughout denotes a highly variable stream where flow is largely from direct runoff, whereas a curve with a flat slope reveals the presence of surface- or ground-water storage, which tends to equalize the flow (Searcy,

The steep slope of the curve for St. Francis River near Patterson, for example,

reflects little storage in the relatively impermeable rocks of Precambrian age that underlie much of the upper part of the St. Francis River basin. Ground-

water storage in this area is relatively low, streamflow is derived mainly from direct runoff, and streams are poorly sustained during periods of little rain. The flatter curve for Current River at Doniphan, however, shows the effects

of the many large springs in the Current River basin which help to sustain

Draft rate in (ft³/s)/mi²

AVERAGE ANNUAL RUNOFF, IN INCHES Adapted from Skelton (1971) **EXAMPLE** Assume that an estimate of storage is desired for a 5-percent chance of reservoir deficiency for a proposed reservoir site near the northwestern corner of Dent County. The desired draft rate is 1.0 ft³/s (449 gal/min, 723 acre-ft/yr or 0.0283 m³/s), and the drainage area of the proposed site is 2.0 mi² (5.18 km²). 1. From the runoff map on sheet 1, the average annual runoff for the site is estimated to be 12 in. (30.5 cm).

EXPLANATION

5. Gasconade River at Jerome

Water years 1924-67 13. Meramec River near Eureka

Water years 1904-05, 1922-67

17. St. Francis River near Patterson

Water years 1922-67 19. James River at Galena

Water years 1922-67

29. Current River at Doniphan

Water years 1923-67

Mean flow

2. Enter the draft-storage relation with the average runoff of 12 in. (30.5 cm). For the desired draft of 0.5 (ft³/s)/mi², $\frac{1.0 \text{ ft}^3/\text{s}}{2.0 \text{ mi}^2} = 0.5 \text{ (ft}^3/\text{s)/mi}^2$ read the required storage to be 360 acre-ft/mi² or, 360 × 2.0 = Note.—This estimate of storage should be increased to allow for

reservoir sedimentation, evaporation, and seepage. Note: Use dashed curves for storage estimates on main stems of the following streams: Meramec River below Maramec Spring; Current River below Montauk Spring; Jacks Fork below Alley Spring; North Fork River below Topaz; and Black River above Clearwater Lake. Do not use curves for drainage areas less than 1 mi² (2.59 km²).

REGIONAL DRAFT-STORAGE RELATIONS PROVIDE ESTIMATES OF STORAGE REQUIRED TO MAINTAIN VARIOUS DRAFT RATES FOR A 5-PERCENT CHANCE OF RESERVOIR DEFICIENCY.—Draft rates are uniform. Storage estimates are not adjusted for reservoir sedimentation, evaporation, or seepage. Sedimentation rates may be estimated from sediment yield data on this sheet. Average annual lake evaporation varies from about 42 inches (107 cm) in the southwestern corner of the area to about 36 inches (91.4 cm) in the northeastern corner (U.S. Weather Bureau, 1959, pl. 2). Seepage losses are highly variable in the area and a detailed study of the geologic setting is recommended for

See Skelton (1971) for storage requirements at gaging stations and for regional

curves for 10-percent and 2-percent chance of reservoir deficiency.

and streamflow data. Consideration was also given to dye-tracing data (sheet 2), field observations following rains, and interpretation of radar and thermal imagery. Other losing areas are certain to exist, but there is a lack of sufficient urrent River at Doniphan (852) asconade River at Jerome (254) James River at Galena (10) St. Francis River near Patterson (8.0) **EXPLANATION** Average recession Maximum recession Minimum observed flow, in cubic feet per second, shown in parentheses Use curves only for the period May through October and for maximum forecast periods of about 30 days. Extrapolations are not recommended Based on data from Skelton, 1970 **EXAMPLE** Assume that the flow of Current River at Doniphan is 1,300 ft³/s on July 1 and that an estimate is desired of the flow 30 days later (July 31), assuming average evapotranspiration rates

This curve should be used for estimates during long periods of extremely hot weather when evapotranspiration rates are ex-BASE-FLOW RECESSION CURVES PROVIDE FORECASTS OF THE AMOUNT OF WATER THAT WILL BE FLOWING IN A STREAM DURING RAIN-LESS PERIODS OF LESS THAN ABOUT 30 DAYS.—Recession curves shown have been reduced by evapotranspiration and seepage losses and therefore do not represent the total contribution from groundwater sources. Comparison of these recession curves shows that the flow of St. Francis and James Rivers is less well-sustained during periods of little rain. The curves for Current and

Enter the average recession curve for Current River at Doni-

phan with a discharge of 1,300 ft³/s and read 32 days from the

time scale. Add the 30-day estimate period to 32 to obtain 62

days. Enter the same curve with 62 days and read a discharge

may be obtained similarly from the maximum recession curve.

A more conservative estimate for the same period (880 ft³/s)

of 1,030 ft³/s as the estimated discharge for July 31.

Gasconade Rivers are typical of streams that are well sustained.

and no surface runoff during the period.

SURFACE-WATER QUALITY

LOW-FLOW FREQUENCY DATA ARE USEFUL IN EVALUATING THE ABIL-

ITY OF STREAMS AND SPRINGS TO SUPPLY WATER FOR MUNICIPAL

AND INDUSTRIAL SUPPLIES, FISH HATCHERIES, WATER-BASED REC-

REATION, AND DISPOSAL OF LIQUID WASTES.—A low-flow frequency

parameter often used for such evaluations is the 7-day Q_x discharge (minimum

average flow for a 7-day period expected to occur at average intervals of x years).

Shown on the above map are the 7-day Q_2 and 7-day Q_{10} discharges for selected

streams and springs in the area. Flows can be expected to be less than the 7-day

 Q_2 discharge at intervals averaging 2 years in length, and the probability that

the minimum discharge in any one year will be less than the 7-day Q_2 discharge

is 0.5. Similarly, flows can be expected to be less than the 7-day Q₁₀ discharge at

intervals averaging 10 years in length, and the probability that the minimum

for many ungaged sites on the above map, care should be exercised in making

such estimates where significant increases are indicated between gaging sta-

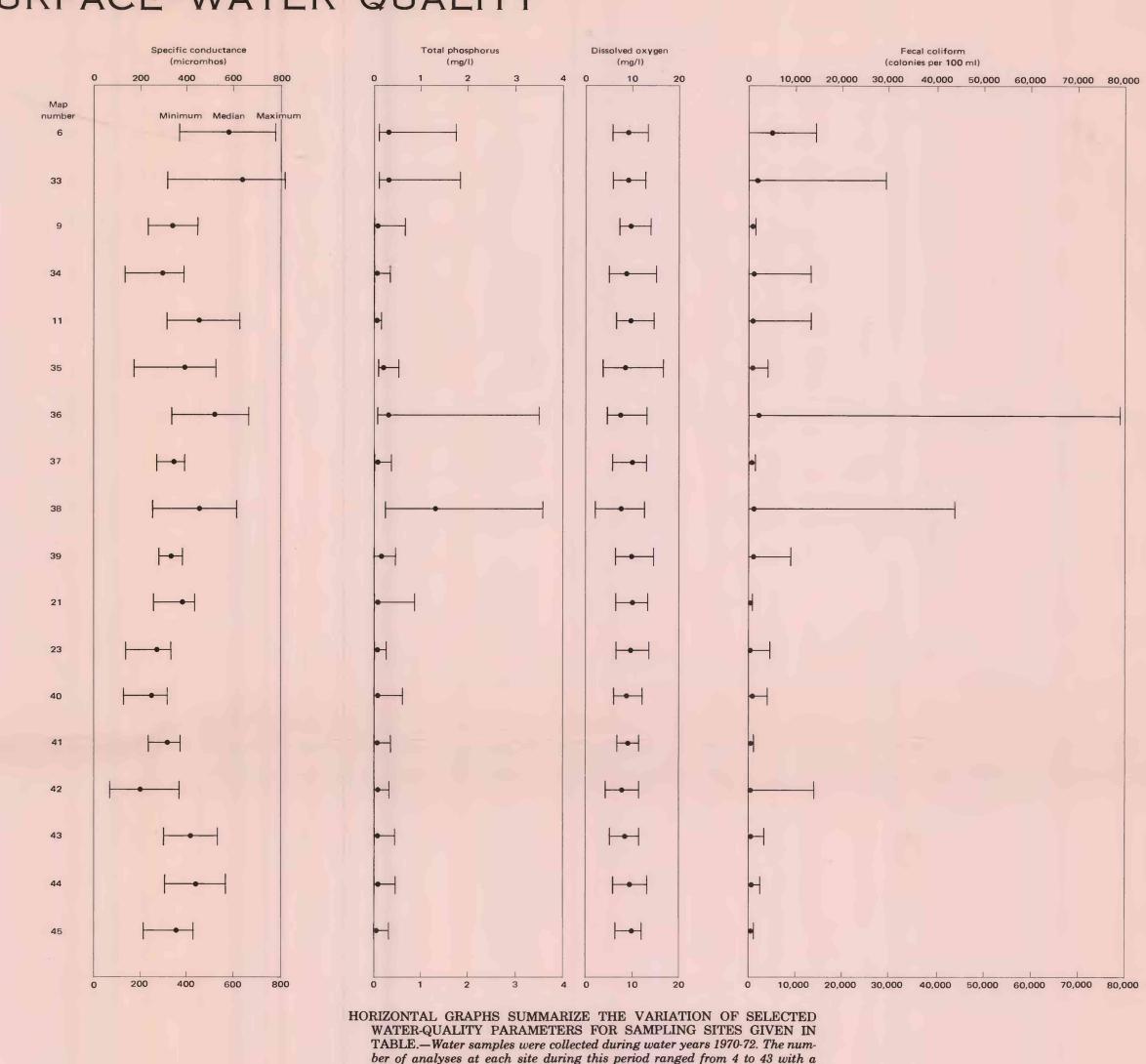
discharge for any one year will be less than the 7-day Q_{10} discharge is 0.1.

Although estimates of the 7-day Q_2 and 7-day Q_{10} discharges can be interpolate

Base from U.S. Geological Survey

State base map, 1:500,000, 1971

Colonies per



median of 33. The range indicated for each parameter was probably exceeded

at most sites during the period. No data are available for 1970-72 at Gasconade

tities of waste effluent have unusually high values of specific conductance, total

phosphorus, and fecal coliform (6, 33, 36, and 38). Minimum dissolved oxygen

values observed during the period were less than 5 mg/l at five stations (34,

Comparison of the above graphs indicates that streams receiving significant quan-

River above Jerome (32).

35, 36, 38, and 42).

EXPLANATION	
Estimated range of sediment yield for drainage areas larger than 10 square miles (25.9 km²)	92°
Tons per square mile per year Acre-feet per square mile per year	
70–300 0.050–0.212	3 (4 55)
300-3,000 0.212-2.12	13 July 18 18 18 18 18 18 18 18 18 18 18 18 18
Assuming an average specific weight of 65 pounds per cubic foot	MARIES 38°
•1	PUT ASKET THE PHEE PS CRAWFORD Sugner Lake Sugner Lake
Sediment discharge station Number corresponds to map number in table	WASHINGTON ST FRANCING ST FRANCING
Area boundary	LACILIDAY DENT
Drainage divide 93°	WRIGHT TEXAS
GREEN Springfills of Circle	SHANNON 10 Charles WAYNE
37°- STUAL S	CARTER
Table Rock and Other Society Francis Control of the Society Fr	OZARK 8
93°	ARKANSAS 92° 91°
	Adapted from U.S. Corps of Engineers (1967); U.S. Inter- Agency Committee on the Missouri River Basin (1969); and U.S. Corps of Engineers, written commun., (1973)

proposed reservoir sites.

Map number	Sediment station	Drainage area (mi²)	Base period (water yr)	Estimated average annual sediment yield for base period (tons/ mi²)
1	Gasconade River at Jerome	2,840	1948-63	136
2	Meramec River at Sullivan	1,497	1945-64	117
3	Bourbeuse River at Union	808	1945-64	132
4	Meramec River at Roberts-			
	ville	2,673	1945-64	233
5	Big River at Byrnesville	918	1945-64	95
6	James River at Galena	987	1922-67	91
7	North Fork River near			
	Tecumseh	561	1945-67	99
8	Bryant Creek near Tecumseh	570	1945-67	125
9	Black River near Annapolis	484	1940-67	100
10	Current River near			
	Eminence.	1,272	1922-67	47
11	Current River at Van Buren	1,667	1922-67	70
12	Current River at Doniphan	2,038	1923-67	106
13	Eleven Point River near			
	Bardley.	793	1922-67	75

ESTIMATES OF AVERAGE ANNUAL SEDIMENT YIELD HELP TO DEFINE THE EROSIVE CHARACTERISTICS OF WATERSHEDS.—Sediment yields are relatively low, about 100 tons/mi² (35.0 t/km²) per year, in much of the area and are highest in the loess-residual soils bordering the Missouri and Mississippi Rivers. Sediment production is highly variable from small drainage areas depending on such factors as soils, topography, vegetation, land use, and climate. Activities such as land grading for subdivision and highway construction, which destroy the existing vegetal cover and expose bare disturbed soil to the erosion process,

may increase sediment yields from local areas by a factor of 10-100.

Interior-Geological Survey, Reston, Va.-1976

100 millilitres Station name 32 06930800 Gasconade River above Jerome¹ 6 06934500 Missouri River at Hermann . . 33 | 06935840 | Missouri River near St. Louis 9 07014500 Meramec River near Sullivan . 34 07016400 Bourbeuse River above Union . . 11 07018000 Big River near DeSoto. 35 07019280 Meramec River at Paulina Hills. 36 07020850 Mississippi River at Cape Girardeau 37 | 07051600 | James River near Wilson Creek .
 50
 24.0
 9.2
 .010
 .080
 61
 7.4
 49
 6.3
 200
 24
 72
 1.7
 15
 2.9
 .46
 1.4
 1.6
 .15
 342
 180
 19
 2.0

 14
 23.5
 8.5
 .020
 .010
 56
 8.2
 6.2
 2.1
 200
 6.0
 12
 .0
 3.4
 .02
 .14
 .120
 .130
 .03
 205
 170
 4
 7.4
 38 07052250 James River near Boaz 39 07052340 Finley Creek at Riverdale. 21 07057500 North Fork River near Tecumseh010 44 24 1.9 1.4 240 5.2 15 .001010 210 9.2
 88
 24.0

 .000

 168
 14
 5.5
 .0

 .00

 166
 140

 7.8

 300
 27.5
 6.9
 .000
 .010
 30
 17
 3.1
 1.2
 176
 6.0
 4.0
 .0
 .5
 .00
 .14
 .040
 .040
 .03
 155
 140
 3
 7.0
 23 07061500 Black River near Annapolis... 40 07063050 Black River below Poplar Bluff 41 07068050 Current River near Doniphan 42 07068550 Little Black River near Naylor. 43 07068867 Fourche River near Middlebrook, Ark.... 44 07069170 Spring River near Thayer.... 45 07071900 Eleven Point River below Bardley. 120,000 | 28.0 | 9.2 | .050 | .080 | 62 | 34 | 76 | 6.3 | 300 | 200 | 72 | 1.7 | 15 | 2.9 | .63 | 1.4 | 1.6 | .15 | 515 | 270 | 19 | 10.0

WATER-QUALITY SUMMARY

Water in most streams in the area is a calcium magnesium bicarbonate type

with a dissolved-solids concentration less than 300 mg/l. Water in streams in the James River basin, which flows on limestone of Mississippian age, is a calcium bicarbonate type with a dissolved-solids concentration of about 200 mg/l. Water

from the Missouri and Mississippi Rivers is a calcium magnesium bicarbonate and sodium sulfate type with a dissolved-solids concentration less than about 500. Limited minor-element data for streams draining mining areas indicate that,

in general, the concentrations of minor elements do not exceed U.S. Public Health

to water from springs which supply much of the base flow (see spring analyses, sheet 2). Analyses shown in the accompanying table are representative of the quality of water during periods of low flow and do not reflect the range in concentra-

tion that might be expected to occur at each site. Mineralization will be less at higher flows because of dilution. The analysis for James River near Boaz (38) is typical of streams receiving significant quantities of treated municipal waste ef-

> CHEMICAL ANALYSES [Analyses by U.S. Geological Survey]

Concentrations of most constituents vary with the flow of the stream and with the season of the year. During periods of low flow, the water is similar chemically

Service's (1962) recommended standards for drinking water.

WATER RESOURCES OF SOUTH-CENTRAL MISSOURI

E. E. Gann and E. J. Harvey U.S. Geological Survey and D. E. Miller Missouri Geological Survey and Water Resources